HOUSE DRAINAGE

G. A. T. MIDDLETON

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A HANDBOOK

FOR

ARCHITECTS AND BUILDING INSPECTORS.

BY

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INSTRUMENTS'

SECOND EDITION, REVISED.

ILLUSTRATED BY TWENTY-TWO PLATES AND DIAGRAMS.

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PREFACE.

In placing this little handbook before my professional brethren, I am actuated by a desire to enunciate in a concise and simple form the now well-recognised principles of a science which, though simple, has only of recent years been fully understood. Owing to the large amount of help which I have received from friends, and especially from Mr. C. E. Gritton, A.M. Inst. C.E., and to the courteous assistance given me by manufacturers, I am enabled to illustrate and describe most of the really good modern appliances and methods.

Those who look for the cheapest possible way of doing drainage work that may comply with the requirements of legal enactments will not find it within. I have aimed at describing only what is absolutely sound, and though a cheaper and a dearer method are in some instances both described,

it is only when both are good, and then the advantage of convenience and accessibility is usually upon the side of the more expensive system.

G. A. T. MIDDLETON.

March 1892.

PREFACE TO THE SECOND EDITION.

IN preparing the Second Edition of 'House Drainage,' the opportunity has been taken to correct various inaccuracies which crept into the first, and to add descriptions and illustrations of a few more appliances. My thanks are due to the reviewers of the First Edition, both for the kindly way in which they reviewed it and for the exhaustive and valuable criticism which they bestowed upon it.

G. A. T. M.

December 1894.

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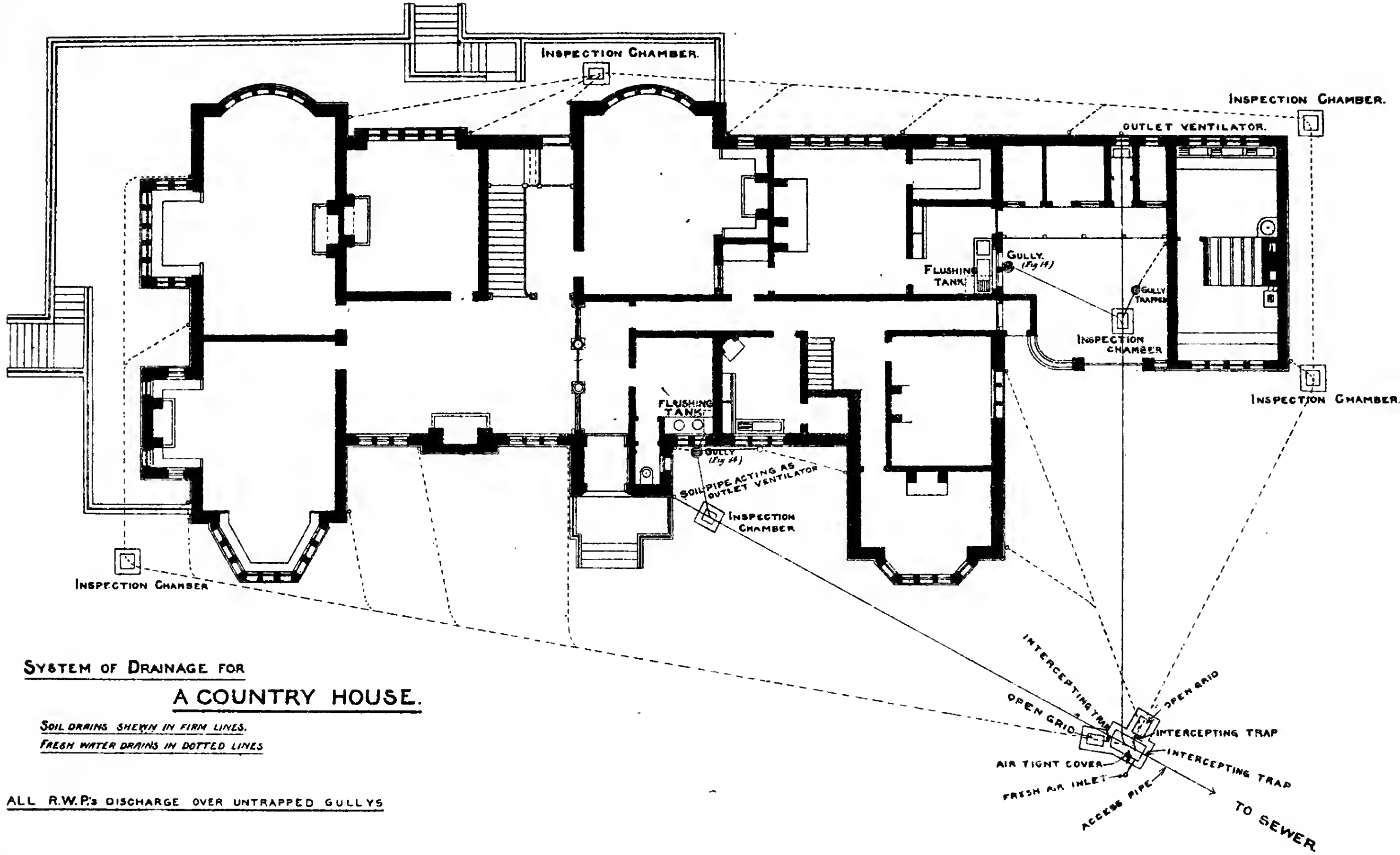

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HOUSE DRAINAGE.

CHAPTER I.

THE MAIN PRINCIPLES.

THE development of sanitary science has at the present time reached a point at which it may be said that the true principles of house drainage have become well established. They can now be definitely laid down with the conviction that if they be departed from the result will not be satisfactory. The details may from time to time, and probably will, be improved upon, but the main principles laid down in this chapter may be said to be agreed upon by all competent sanitary engineers, and to admit of but little variation so long as the present all but universal system of the carriage of sewage by water obtains.

The first essential, and the one which has been generally admitted for the greatest period of time, though it has only been of comparatively recent years carried out efficiently, is that the house drain should be disconnected from the sewer by means of a self-cleansing intercepting trap, placed as near to the sewer, in the line of the house drain as

circumstances will permit. It is best to place this trap so that access can be had to it from a manhole (or disconnecting chamber, as this particular manhole is called), but this is not essential under all circumstances.

It is essential, however, that an inlet for fresh air should be arranged into the house drainage system upon the house side of the intercepting trap, and as near to it as possible, and that provision be made against its acting as an outlet instead of an inlet ventilator unless its mouth be so placed that this be immaterial—and this is rare.

The drain pipes must be laid on a solid foundation of sound material, and with perfectly watertight joints, and they must be in perfectly straight lines from point to point with an uniform fall. In all first-rate work there should be small manholes (called access or inspection chambers), with air-tight covers, wherever curves are necessary or important junctions are formed, but in places where economy is of high importance ordinary bends and curved Y-junctions may be used: but it must always be remembered that it is at such places that stoppages occur, if at all, and that the provision of an inspection or access chamber may save much subsequent trouble and expense in opening up ground, while if the pipes be straight from chamber to chamber, even these pipes, and so the whole system, can readily be cleared of obstructions, if necessary, by means of rods. Drain pipes may only pass under a house or outbuilding when

this is unavoidable, and then special precautions must be taken against leakage, and an inspection chamber, with *double* air-tight cover at each change of direction, becomes a necessity.

The soil-pipes must be of iron or strong "hydraulic-drawn" lead piping, fixed and jointed in a permanently secure manner, particular attention being paid to the formation of all joints, and must be carried full bore at least 5 feet above the eaves of roof or of any dormer window opening on to roof, and well away from all chimneys, house ventilators, &c., and finish without any other covering than is sufficient to keep birds from building their nests in them, and to prevent down-blow. They normally serve as outlet ventilators, their mouths being at higher level than those of the inlets. Soil-pipes must be carried outside the house wherever possible.

The form of closet to be used depends greatly upon circumstances, but it is essential that it be efficiently trapped by a trap *immediately* under it, that provision be made against the trap being "syphoned out" (that is, against the water being pulled out of it by suction on the discharge of other closets or flush-tanks) or "momentumed out;" that it be self-cleansing; and that any joint between lead or iron and stoneware pipes be made on the house side of trap or under the water seal. "Stoneware to stoneware, lead to lead, and iron to iron," is the best rule.

The positions of closets and urinals should be

carefully chosen, that they may be well lighted and ventilated, and, if possible, cut off from the rest of the building by a lobby having through cross ventilation.

A separate water supply should be arranged to closets, slop sinks, and urinals to that which serves for other purposes. Whether the water be admitted into the house upon the constant or intermittent system, small disconnecting cisterns, discharging a sufficient and definite flush of not less than three gallons at each pull of the handle, should be arranged to each apparatus.

All waste-pipes from sinks (except scullery sinks and slop sinks, which latter are best treated as closets), baths, basins, and rain-water pipes must be taken to open circular gullies, which must themselves be trapped, and whence small branch drains may be taken direct to soil drains, but they are better taken in straight lines to the nearest inspection chambers, joining the soil drain there. Often these are carried by an entirely distinct system of pipes from that conveying the soil and grease, to a ventilated disconnecting trap, which itself empties directly into the main disconnecting chamber. In such a case the soil drain must be at the lower level.

All overflows, whether from cisterns, or from drip-trays under closets, baths, or cisterns, should discharge directly into the open air, in as inconvenient a place as possible, so that any leak or stoppage causing an overflow would be certain to receive immediate attention. Such a discharge over a

door, or with a fall on to a conservatory roof, is sure to call attention to the matter. The outlets of such pipes should be protected by small flap-valves to prevent a draught of cold air into the bath or water-closet in question.

It is well to collect clean water into an automatic flush-tank in such a way as to cause a periodical discharge through the whole of the main drainage system of a large house, while in smaller houses the rain water may be utilised for this purpose, provided proper rain-water separators be used, though the flush is not obtained at regular intervals, and will probably be missing in the summer months almost entirely.

All stable drainage should be taken to the outfall by a distinct system of its own, not passing near to the house: but at times it is, from the positions of stable and outfall, obliged to pass either under or close past the house. This, however, is not good; though it should be rendered perfectly safe in either case by the application to the stable system of exactly the same precautions of construction, disconnection, ventilation, and flushing as must be applied to house drainage, bearing in mind that stable sewage, &c. is particularly liable to cause stoppages in pipes and traps, and should consequently not be admitted to the drains.

It may be taken as a maxim that all drains should be as small as possible, for it is only when running fairly full that they can be considered to be self-cleansing; and for the same reason they

should have an occasional full-bore flush passed through them from syphon flush tanks.

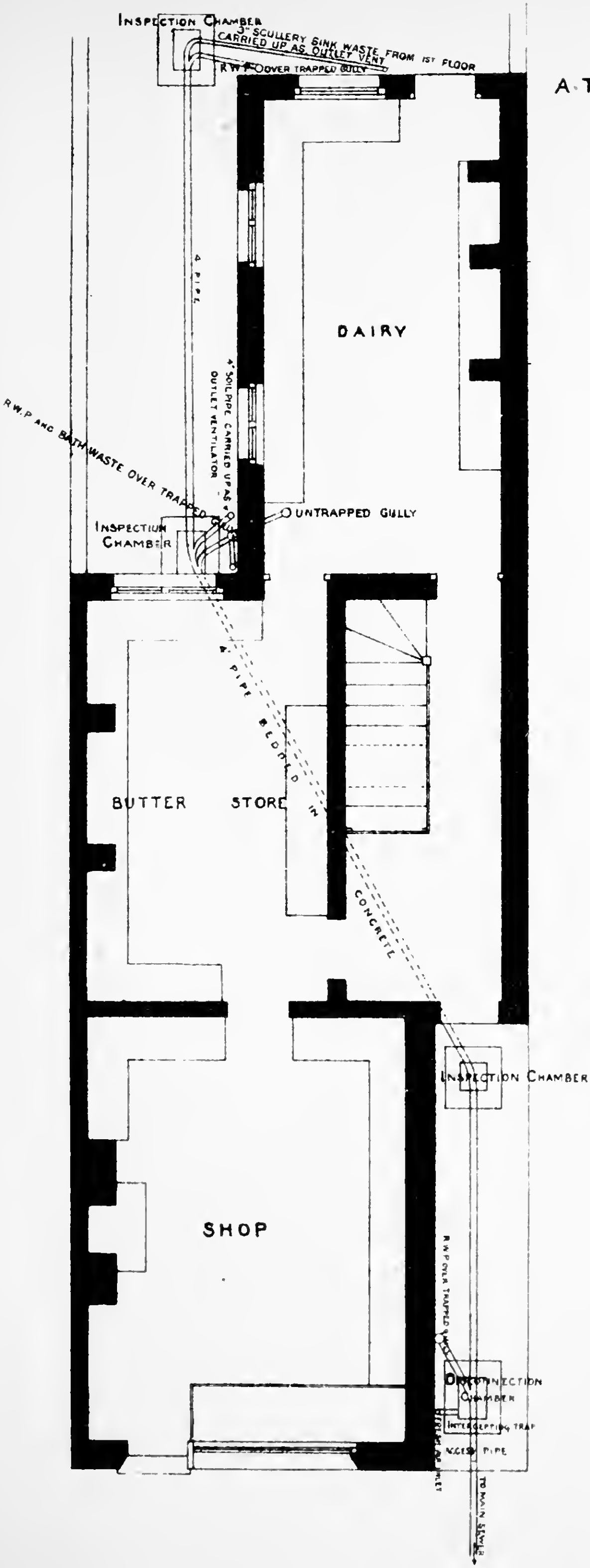
On Plate A is shown the system of drainage adopted in a large country house, with soil drains shown in a firm line and fresh-water drains in a dotted line; these latter having distinct systems, disconnected from soil drains at the point of discharge into main disconnecting chamber, whence all are taken direct to sewer.

Plate B shows the scarcely so complete system generally adopted in a small terrace house; but here, too, all wastes are properly disconnected before discharge into soil drain.

It will be noticed that in both these systems a constant current of air is provided through all pipes.

Plate B.

A TERRACE SHOP



CHAPTER II.

THE DISCONNECTION FROM SEWER.

THE means of disconnection of the house drain from the sewer (or from the special system for disposal of sewage in the case of an isolated country house) is shown on Plates A and B as being accomplished by means of a disconnecting chamber, such as is shown to a larger scale in Plate C, Fig. 1. The chamber is built of hard brickwork in cement, with cement concrete bottom, laid with careful falls in all directions to the channels through it. Often it is lined with glazed bricks, but an inside rendering of cement and sand is equally good — while the concrete bottom should, of course, be also coated with trowelled cement. The straight channel is formed of a half-round glazed stoneware pipe, generally white enamelled, and should be laid to a steeper gradient than is the house drain—not less than $1\frac{1}{2}$ inches in the 2 feet length; as should also the curved junction pieces, which must be carefully chosen so as to secure the proper curve to throw the discharge from branches into the line of flow of the main, and to avoid splashing the sides or

blocking the outlet from any other branch. No two, therefore, should discharge opposite one another—and they should be so placed as to discharge over the side of the half pipe forming the main channel, and not at invert level. The best junction bends are those made by Messrs. Winser & Co. They are three-quarter pipes of proper section for each radius, with flat base, so that they can scarcely be laid wrongly. The main channel should be carried up 3 inches vertically on either side, with glazed bricks laid in cement.

The most important thing in connection with this disconnecting chamber is undoubtedly the intercepting trap itself. Of this there are very many first-rate forms in the market, prominent among these being Angell's (shown in Fig. 3), Winser's, Broad's, Crapper's 'Kenon," and Cliff's "Beancliffe." All the best traps are contracted at the bend, to prevent them from being "momentumed out," and are lower at the outlet than the inlet, while they must be quick in curve to be self-cleansing, and almost vertical in drop.

Fresh air must be admitted to the drain immediately upon the house side of the trap. When dealing with country houses, with the inspection chamber far from any dwelling, there is little objection to doing this by forming the chamber cover with an open grid, admitting the air unrestrictedly : but when dealing with town houses, it is in all cases advisable, and often absolutely necessary, as when the inspection chamber is in a

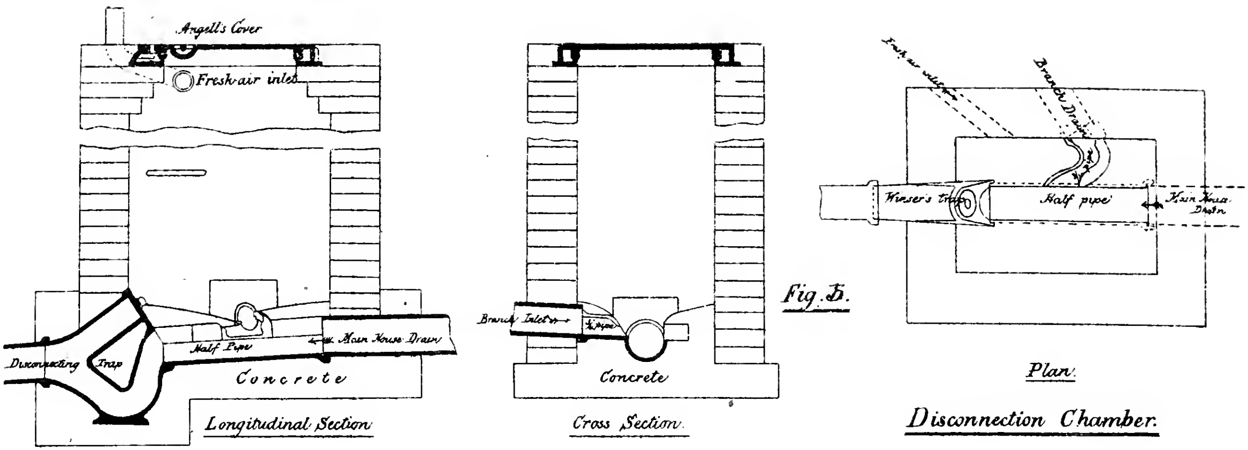


Fig. 5.

Disconnection Chamber.

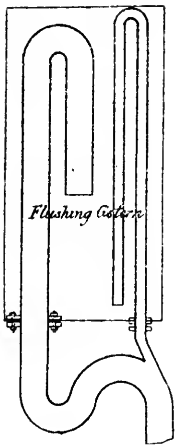
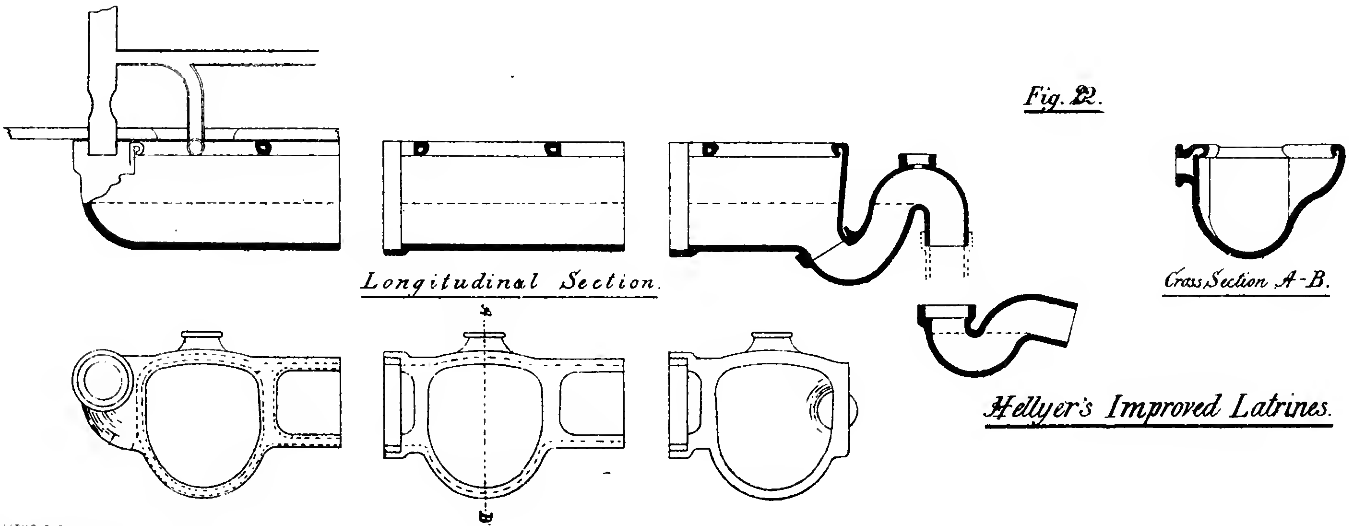



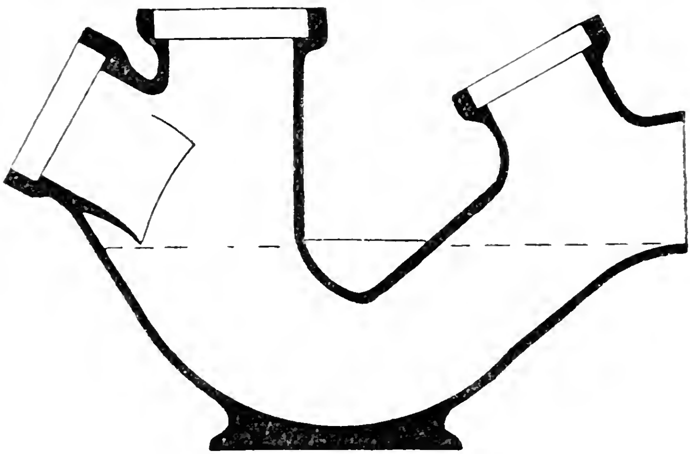
Fig. 2.

Hellyer's Improved Latrines.

C F KELL PHOTO-LITHO 8 FURNIVAL ST HOLBORN E C

front area, or in the rare cases when it is unavoidably within the house itself, to provide an air-tight iron cover, such as that made by Mr. Angell, and shown in Plate C, Fig. 1, and again in greater detail in Fig. 5. Its seal is formed with a felt-like packing impregnated with a greasy substance, which

Fig. 3.



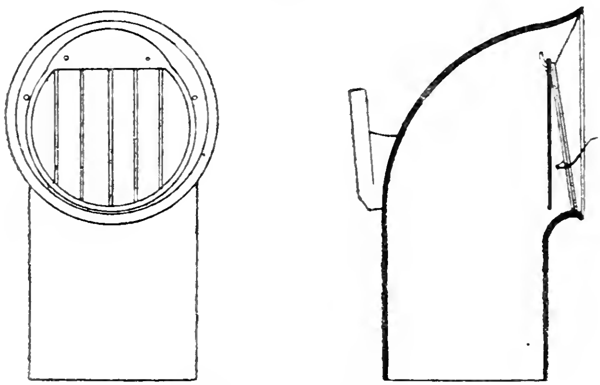
Angell's Intercepting Trap.

neither hardens in course of time nor softens overmuch with heat, and is made to hinge and lock with a key, but when open the cover can be entirely removed. Then there should be carried up a separate ventilating pipe, generally of 4 inches diameter, from the disconnection chamber, as shown in Plate C, Fig. 1, ending in the open air about 2 feet above ground level, with a mica-flap air inlet, of which the best form is shown in Fig. 4. Normally,

the flap hangs loose upon its hooks, allowing of the ingress of fresh air to the chamber, and so to the drain, but in the event of an occasional reverse current the flap is blown at once against its seating, and stops the orifice, thus preventing the foul air from the drain from coming out.

Of course, to ensure proper ventilation of the drain, it is necessary to provide an outlet for foul air as well as an inlet for fresh, with no trap or

Fig. 4.

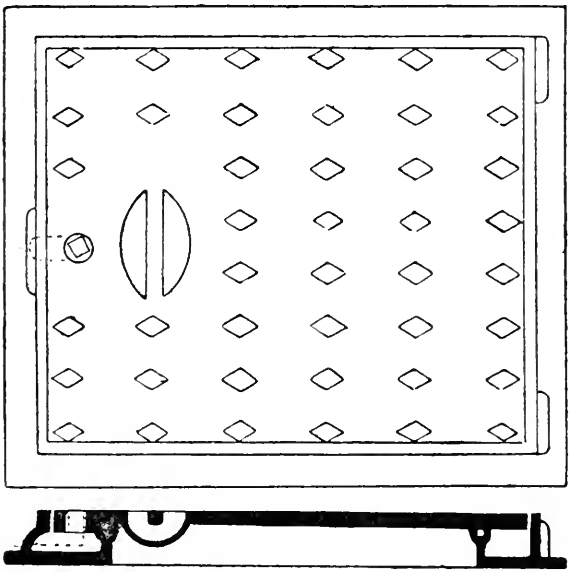


Mica-flap Air Inlet.

other impediment to the air current between ; and this is usually secured by carrying up *all* the soil pipes, full bore, at least 5 feet above the eaves, or any adjacent dormer window. These should conclude with simple cowls, having a sufficient cone-shaped cover to prevent down-blow, but with ample room for the air to escape round the sides, the form shown in Fig. 6, made by Messrs. J. E. Ellison & Co., of Leeds, being perhaps the best

now made. It is well to surround the opening with wire netting to prevent birds from getting in and building nests. Low-level inlets and high-level outlets promote and sustain a constant stream of ventilation, under normal conditions, due to the different pressure of the atmosphere at different

Fig. 5.

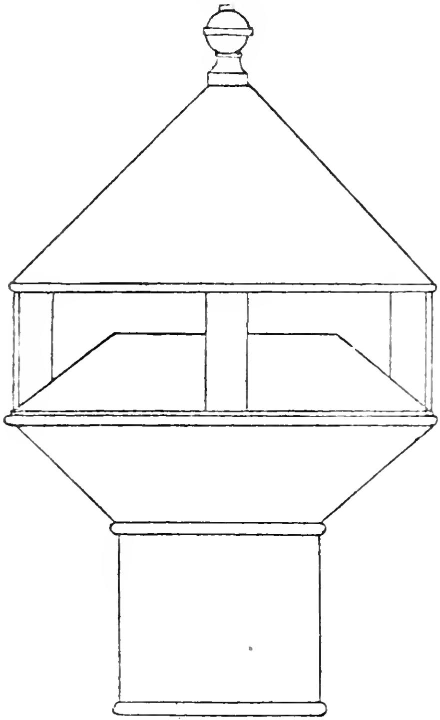


Angell's Air-tight Manhole Cover.

altitudes, but reverse currents occur at times, as when a closet is discharged, and the mica-flap valve at the inlet is a necessity. Some authorities, however, prefer to make both inlet and outlet at the same high level, leaving the inlet as a simple open pipe, saying that it does not matter then

which way the current flows; but the result is stagnation, and no current at all under ordinary circumstances. Other authorities advocate the omission of the mica flap, even from low-level

Fig. 6.



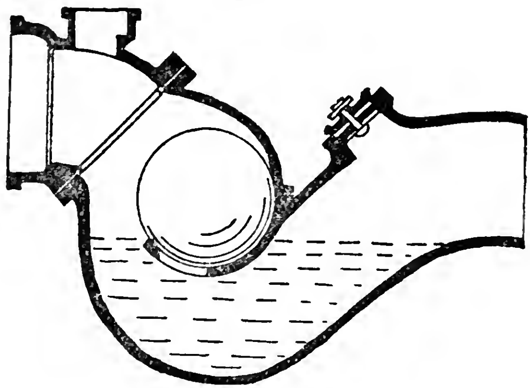
Stevens' Cowl.

inlets, upon what appear to the author to be insufficient grounds.

The disconnection from the sewer is often made by means of a trap only, having an eye upon the house side for the connection there of a pipe to

form the inlet ventilator, there being no disconnection chamber. This is frequently done with small houses, where the expense of building a chamber would be too great, and is perfectly safe, although if ever a stoppage were to occur the ground would have to be opened up to ascertain the cause, and the cost of doing this would soon exceed that of the building of a chamber in the first instance—to say nothing of the inconvenience of having up the

Fig. 7.



Tidal Trap Valve.

drains of an inhabited house. Most manufacturers of traps make them to suit these circumstances, as well as for insertion in chambers, that shown in Fig. 3 being Angell's lipped trap, the lip being used to throw the sewage well forward to the middle of the trap. Theoretically, it looks as if the lip would foul underneath, but in practice it is not found to do so.

It occasionally happens that provision has to be made against tidal or storm water backing up the house drain from the sewer. The best means of doing this yet devised is by using a tidal valve and trap such as that made by Mr. Botting, and illustrated in Fig. 7. It will be seen that the trap, made of iron, is of much the usual form, but it is provided with a ball, which rises and bars the way on water backing up the trap.

CHAPTER III.

PIPES AND JOINTS.

THERE is considerable difference of opinion as to whether stoneware or iron pipes are best for house drainage, but all are agreed that no other material than these should be used.

If stoneware pipes be employed, they, like all stoneware goods, should be true in shape, hard, vitrified throughout, and salt-glazed all over. Where curves are necessary, curved pipes should be used, to as slow a radius as possible, in order to avoid the sudden stoppage to the flow caused by a quick curve—curved *pipes*, so that the joints may be perfect. Junctions must in all cases be made in the direction of the flow—never at right angles: for though all junctions are best made in inspection chambers, yet there can be no objection to joining short branches from soil pipes (they should be as short as possible, say with a maximum length of 10 feet) direct to the main. To join a similar *short* length from a gully trap (say less than 6 feet in length) is risky, as such a discharge as that from a flushing tank down the main and past the junction has a very powerful pulling action, and might easily syphon out the trap. The main

drain should be in a perfectly straight line from one inspection chamber to another, where the chambers are used, or from bend to bend where they are not, and to perfectly even falls. Round curves this rate of fall should be doubled, and all branch connections should also be to even falls, in a bee line from foot of soil pipe, for instance, to junction with main, and all the way in the direction of flow of main.

When laying stoneware pipes it is necessary to see that they are supported throughout their length, and not at the sockets only, as is more often the case than not. If they be in a good firm subsoil, for example, there should be slight sinkings made in the trench every two feet in length for the sockets to drop into, while if a concrete base be needed, as it is whenever there is the slightest doubt about the subsoil, then a brick should be inserted in the concrete where each socket will come, this brick being removed when the pipes are laid. As has been previously said, when pipes are obliged to be carried underneath a building they should not only be thus laid on a Portland cement concrete bed, but, when the pipes and joints have been tested, should be completely encased in at least 6 inches of similar concrete.

The joints in stoneware pipe drains should be formed in good Portland cement and sand in equal proportions, laid in the socket before the spigot is driven home, a fillet of cement being

run round the outside of the joint afterwards, and the inside wiped out carefully to preserve the true bore of the pipe without obstruction. The composition joints known as Stanford's, and as Messrs. Doulton and Co.'s, are also excellent, especially if this cement fillet round the outside of joint be added; and they possess the advantage of allowing a drain to be very rapidly laid—sometimes a most valuable one.

It is of the utmost importance that cement, or one of these patent composition, joints *only* should be permitted to stoneware pipe drains, and care should be taken to see that cement joints are properly made *all* round the pipe.

Most of the above remarks equally well apply to iron drain pipes, which certainly possess the advantages of strength and power of resistance to sudden jars over those of stoneware, and so should be employed in preference to them if the drain pass beneath a carriage way and less than 3 feet from the surface. They are scarcely so durable, however, for in time they rust, while good stoneware is practically imperishable. Of course no iron pipe should be employed unless it had been subjected to some preservative process.

They can be Bower-Barffed (subjected for some twelve hours to the action of superheated steam, after having themselves been raised to a very high temperature, and so coated with the black oxide of iron), or, when heated to a less degree, they can be dipped into Dr. Angus Smith's composition, also

highly heated. Neither of these processes is perfect, however, for a comparatively slight accident will chip off the oxide coat formed by the first, while the second is practically much the same as japanning, and the preservative coat slowly wears away, the life of a drain pipe thus coated being about 40 years.

The joints of iron pipes can be safely made in several different ways, but perhaps the most satisfactory is to use simple socketed pipes, and to fill in the joint with tow and lead—though the "rust joint," formed of iron filings and sal-ammoniac, is also excellent, and easy to make.

Should it be necessary to joint iron to stoneware, it is probably best to do this with sulphur, run in in a molten state, though a cement joint, formed as above described, is more usually employed.

Possibly the most difficult joint in the drainage scheme of an ordinary house is that at the foot of a lead soil pipe, where it enters the iron or stoneware drain. Of course the bend at the foot of the vertical pipe should be made of the harder material, for the soft lead would in time be beaten out of shape by the constantly falling water; so that the lead pipe falls vertically into the socket of this bend. Lead and iron are most difficult to join satisfactorily, on account of their galvanic affinity for one another, and of their different behaviour under changes of temperature. A copper or bronze ferrule, having a flange on its lower extremity to

rest in the socket of the bend, should be "wiped" on to the lead pipe, and placed in position in the socket. The choice of a filling rests between Portland cement and sulphur, either being good. In order to prevent either escaping into the inside of the joint and forming an obstruction it will be necessary to first lay a little tow in the bottom of the socket, then to place the lead pipe in position, and then pour in the sulphur or work in the cement by hand. If the drain be of stoneware the joint is made in the same way.

Wherever a joint has to be formed between materials of a different nature, it should, if possible, be entirely embedded in concrete, after having been carefully made; and, in the case of the joint at the foot of a soil pipe, the bend should also be supported on a solid concrete bed.

All lead pipes are now made of strong hydraulic drawn piping, without seam, and for soil pipes should be of 7 lb. thickness; that is, a 4-inch pipe should weigh 7 lbs. per foot run at least. Such pipes should be absolutely straight from entrance into drain-pipe bend at foot to outlet above the roof, the plinth, mouldings, and eaves gutter all giving way to them. They should, wherever practicable—and it should be made a *sine qua non* in planning any building to make this practicable—be external to the building entirely, and in no case laid in chases in the wall, as in such places they are difficult to repair, and the making of the joints is rendered very awkward.

All joints in lead pipes, for whatever purpose they may be used, should be " wiped " joints, formed by opening out a socket on the upper end of the lower of two pipes to be joined, with the turning pin, shaving off the spigot of the other pipe to a proper angle to fit, rubbing tallow or some other flux over the parts which are to meet the solder, fitting spigot into socket, pouring molten solder in, and with it, with the help of a cloth, wiping on a broad roll of solder round the outside of the joint.

Where one lead pipe joins another, as where the pipe from a closet joins a soil pipe, it is best to have the junction beaten up out of a sheet of lead by a highly accomplished workman ; but this is expensive and difficult, and the joint is frequently formed by what is known as " burning," also a difficult process. A soldered joint should not be permitted there, as the entering pipe is almost sure to project into the soil pipe, and cause an obstruction to the flow from the closet above, should there be one. Probably before very long these junctions will be able to be obtained hydraulically drawn, without joint.

An objection which has often been raised to the use of lead soil pipes is their tendency to " creep " downwards in hot weather, owing to their low melting temperature, and this can only be obviated by securing them at frequent intervals to the wall.

Iron and stoneware have both occasionally been used for soil pipes, but it is difficult to make sound

vertical joints with either (though Robin's cup joints for iron pipes, rusted up, may overcome this difficulty); and the latter are heavy to support and most unsightly, while the connection from closets is exceedingly difficult to make with the former.

Whatever pipes are used, in whatever position, it should be borne in mind that they should be as small as possible for the work which they have to do, it being borne in mind that a pipe is most self-cleansing when running about three-quarters full. Thus a 4-inch soil pipe is amply large enough under almost all conditions, as is a 4-inch drain, even when it picks up scullery and bath wastes and several rain-water pipes. In fact, 4-inch is quite large enough for the drains from the largest private house, and even from a small boarding school or hospital up to a capacity of, say, sixty residents.

Unfortunately, according to the Bye-laws of many districts, no drain pipe of less than 6-inch diameter is permitted to be used for soil drains. As this insanitary regulation can be legally enforced, it has to be submitted to; but it may be pointed out that it does not necessarily include the trap. A diminishing half-pipe, 6-inch to 4-inch, can be used in the chamber, and an increasing trap, 4-inch at intake and 6-inch at outgo, can be used; a self-cleansing trap being thereby provided upon a small drain in spite of ill-devised local Bye-laws.

Finally, when the earth is filled in to the trenches, around and above drain pipes, it should only be carefully packed and beaten down with the flat of the spade—and not on any account rammed until there is quite 3 feet of earth filled in above the pipes, else the latter are liable to be broken.

CHAPTER IV.

WATER-CLOSETS, SLOP SINKS, AND URINALS.

IT is strange that in spite of the large amount of attention which has been paid to the perfection of water-closet apparatus, but very few forms should be really satisfactory—yet such is the case. Whole classes of apparatus, once almost universally used and even now frequently introduced, have to be condemned from one cause or another.

The pan-closet, with its container and D-trap, it is to be hoped needs little attention here, for in every detail it is as bad as it can be; and the "long hopper," still often used in basements and for servants, should need as little, being always in a more or less filthy state, and with the water so introduced as by no possibility to cleanse it.

These two old-fashioned forms of closet contravened every rule which should govern the choice of an apparatus.

Above everything, it should be self-cleansing; and the trap pertaining to it should also wash clean at each discharge, and be left with only clean water in it; while, if the connection be to a soil pipe (i. e. not direct to a stoneware drain, as can be managed in basements, and sometimes on ground floors, if

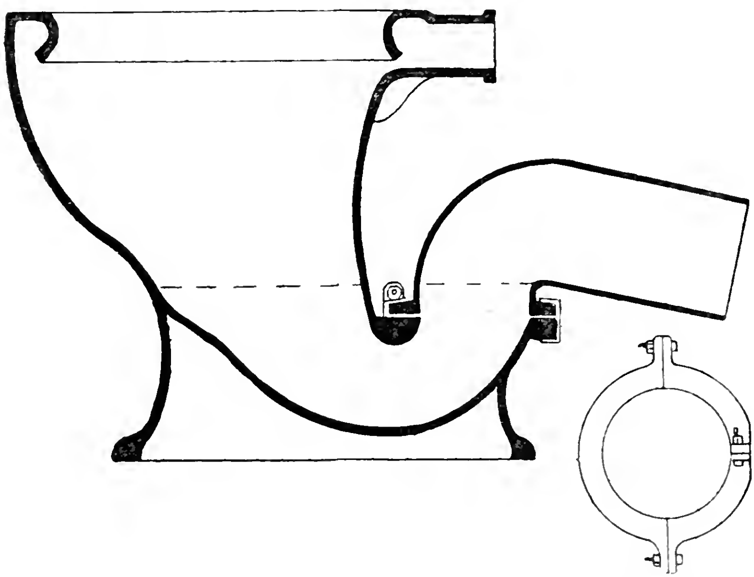
there be no basement under), then the joint between the stoneware and the lead, which is a difficult one to make soundly, must on no account occur inside a building upon the drain side of the trap.

There is a third class of apparatus very greatly used at the present time, which cannot fulfil these conditions. No wash-out closet, even of the best form, should ever be used. They are very far indeed from being self-cleansing, in spite of their flushing rims, having insufficient depth of water in their pans, and a drop thence to the trap, which drop is almost invariably in an insanitary condition. The traps, too, even if they be of good form so as to flush through readily, possessed of sufficient seal, and having no "inspection holes" or other contrivances to form a place of lodgment for the excreta—and it is rarely that they are so formed—are scarcely ever cleansed through and left with clean water in them after the flush; for the force of the flush has been broken in the attempt to clear the pan. Of course, the pan and trap being in one piece, the joint between stoneware and lead occurs on the soil-pipe side of the trap, where any leak would be a leak of sewer gas, drawn in by the warmth of the house.

This last objection can be urged against many otherwise fairly satisfactory closets, and disappears when the connection can be made direct to stoneware. This is particularly the case with closets of the "short-hopper" class, many of which are perfectly admissible in such a situation. For them

to be self-cleansing they must have flushing rims, and the back should be almost, though not quite, vertical. The greatest defect as a rule is insufficiency of water area (there is plenty of depth), leading to soiling of the sides. The trap is best in one piece of earthenware with the pan—if not, a P-trap should be selected. In such a case the trap

Fig. 8.

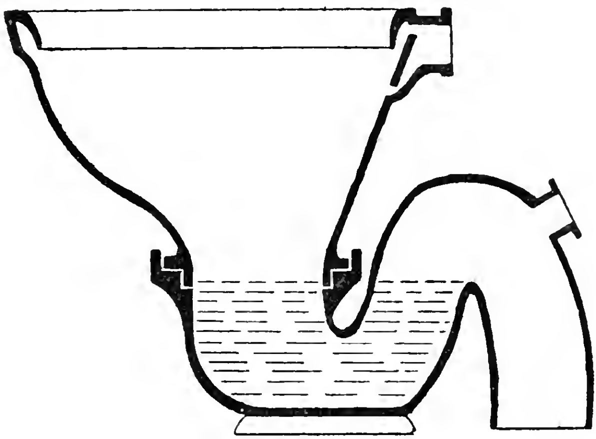


The "Puro" Closet. Plan of Metal Clip.

can be made in lead, and then, and then only, may such closets be used with connection to lead soil pipe. Some of the best closets in the market belong to this class, of which it is only necessary to mention Hellyer's "Hygienic" and Winser's "Puro" (see Fig. 8), the latter of which is as nearly perfect as

any yet introduced, and may be used in all circumstances, the bend to complete the trap being provided either in lead or stoneware, being so connected as to turn in any direction, and if in lead having the connection made by a special arrangement of a bolted iron collar, helped with a little red lead. There is ample area and depth of water, no likelihood of soiling the pan, and

Fig. 9.



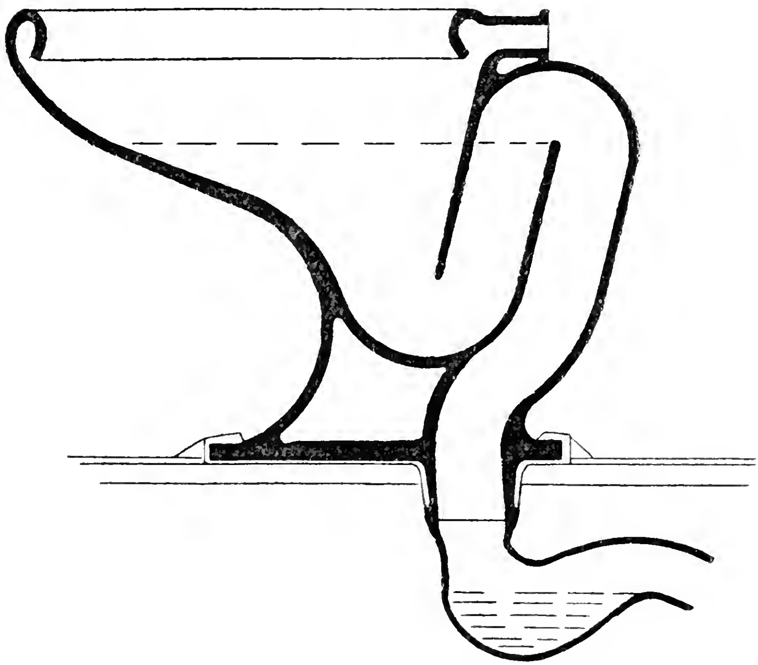
The "Swift" Closet.

an easy trap, in full view, with good seal, which is completely cleared even with a two-gallon flush—though more should be provided if the regulations of the company supplying the water will allow of it. Hellyer's "Hygienic" is equally good if properly fixed, while there is an excellent cheap closet, known as the "Swift," which may be used safely when the connection is direct to stoneware—though

the water area is small and depth too great for easy cleansing. It is shown in Fig. 9.

Another first-rate apparatus is the "Dececo," by the same maker as the "Puro" (see Fig. 10). It has a very deep seal (some 7 inches) and a long syphon

Fig. 10.



The "Dececo" Closet.

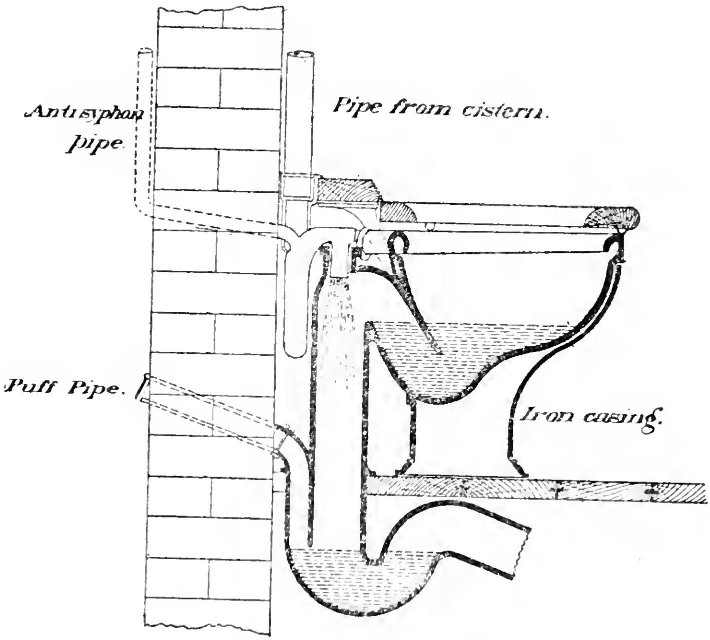
arm behind the almost vertical back, discharging into a lead weir with a contracted outlet. A three-gallon flush is a necessity with it, and a special arrangement for after-flush with distinct interval of time between the flush and after-flush; and so it is an expensive closet. When the flush comes, the water

falls down the long leg of syphon, chokes the contracted outlet of weir and sets the syphon in action. When the pan is completely syphoned out, save enough water to fall back and just seal the trap, the after-flush raises the seal to a sufficient depth. The joint between the lead weir and stoneware syphon is upon the wrong side of the trap, but in case of an air leakage there the syphon would cease to act, and, therefore, it is safe, as then means would at once be taken to repair the damage. Slops should *never* be poured down this closet, as they may set the syphon in action and leave but a slight seal in trap. Another closet of the same class as the "Dececo" has recently been introduced by Mr. G. Jennings, under the name of "The Closet of the Century" (Fig. 11), in which the syphon is set in action by a spray obtained by choking the supply pipe. It is of more complicated construction, but appears to work well, while the higher position of water-level, and the fact that there is no risk of syphonage if slops are poured down, constitute advantages in its favour.

Perhaps the most satisfactory class of closets, taken upon a whole, is that of the "Valve," but the majority of those in the market, if examined carefully, will be found to have some mistake made in the manufacture largely militating against their safety; while none can be used with the waste-preventer cistern now almost universally insisted upon by water companies, for the valve will remain open as long as the handle is held, and

if this be held too long there will be no more water left in the cistern to fill the pan after the handle is dropped. Essentially, they all consist of a stoneware pan, with iron valve box under, containing a valve held up tightly against the outlet of pan by a

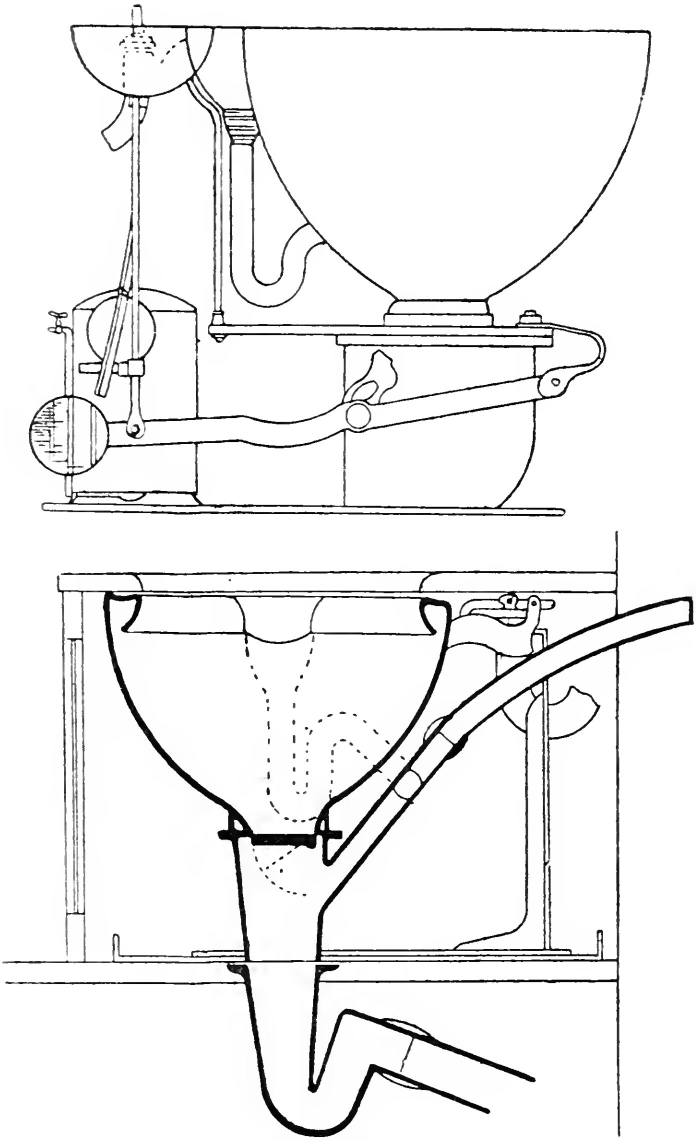
Fig. 11.



The "Century" Closet.

heavy weight on the end of a lever until the weight is raised by lifting the handle. Below the valve-box again is a lead trap, best of the "P" form, or else Hellyer's "Anti-D," the form shown in Fig. 12, which illustrates Hellyer's valve-closet—one of the best, if not the best, in the market. It will be

Fig. 12.



The "Optimus" Valve Closet.

noticed that the overflow from the pan discharges behind the valve into the valve-box, so that its outlet cannot become choked, while a ventilating pipe is so provided as to ventilate the valve-box and at the same time prevent syphoning out of the overflow during a discharge. A special locking arrangement prevents leakage at the valve save from injury to the rubber seating, which can readily be repaired. An air cylinder provides for an after-flush after the handle is dropped, which can be regulated to any required amount, and in all valve closets this should be so managed as to discharge some water down the overflow pipe at each discharge, to keep its trap sealed.

Where several closets discharge into the same soil pipe, one above the other, all save the highest of the series requires to have what is known as an anti-syphonage pipe branching from just beyond its trap into the open air, so as to prevent the trap from being unsealed by syphonage when another closet above it is discharged. A small pipe ($1\frac{1}{2}$ inches) will suffice, and it is usual for all such pipes in a vertical series to be connected by a vertical pipe outside the wall of the house, and eventually to enter the soil pipe *above* the top connection from a closet or housemaid's sink for slops.

Slop sinks are as a rule best avoided, or if used should be treated precisely as closets: and in fact no better slop sink can be found than one of the "Puro" closets with a sink rim (such are made specially) attached. Slop sinks should always be

provided with some simple contrivance to discharge the flush whenever they are used, as servants are liable to be very careless about flushing with water after emptying slops. Slop sinks should be placed in well-lighted and well-ventilated chambers—not in dark and dirty out-of-the-way cupboards ; and this remark applies with equal force to water-closets.

The system now generally adopted in hospitals of placing such conveniences in an annexe with a ventilated passage between it and the main building is one which should be followed wherever it be possible, even in private houses : and in any case they should be kept well away from places for the storage of food.

All the closets mentioned above should have lead safes underneath them to catch any water in case of an overflow or leakage—for though such should never occur it may do so occasionally. Where lead is objected to on account of its appearance, a stoneware sink might be substituted, such as is used in sculleries. Lead waste pipes have to be taken from these and should discharge through outer wall into the open air, over a conservatory roof, or a front door, if possible, or at any rate into some other position where any discharge would, from its very inconvenience, be noticed and remedied at once. Such waste pipes, like the overflows from baths, lavatory basins, and storage and waste-preventer cisterns, and the wastes from similar safes under baths and lavatory basins,

which should be treated in precisely the same way, should have small hinged flap valves at the outlet to prevent back draught of cold air.

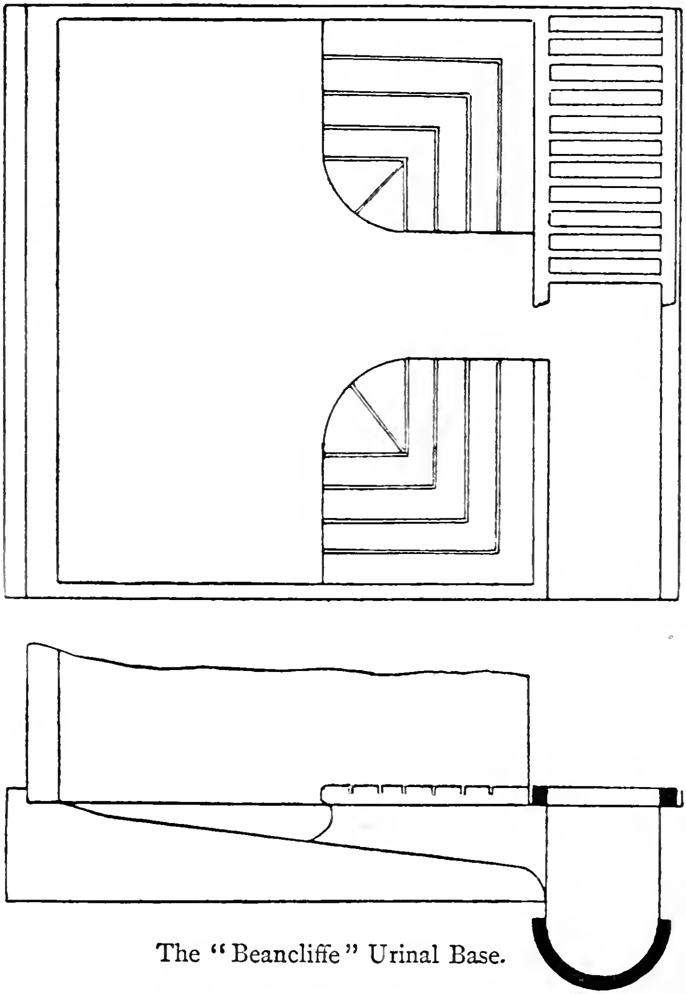
Closet casings should be avoided, as forming but a space for the harbour of dirt.

Where a range of closets on the same level (generally the ground-level, with direct connection to stoneware pipe) has to be provided, it is certainly best to treat each separately; but in many cases, as in schools for young children, especially of the poorer classes, and in barracks, it is impossible to depend upon the flush being discharged after the closet has been used. Several arrangements to meet such cases are in the market, but undoubtedly the best is Hellyer's "Improved Latrine," shown in Plate C, Fig. 2. Any number of closets can be arranged in series, joined by socket joints to one another, with separate water supply to each acting with a flushing rim, and with a special flushing cistern, discharging through a syphon when full, flushing the whole series, and immediately putting the syphon at the outlet into action, having a considerable and clever after-flush to fill the series of pans with clean water after the discharge. The arrangement of the syphon is similar to that of Winser's "Dececo" closet, and provides for the thorough cleansing of the whole series at each discharge.

Urinals are always difficult to make satisfactory from a sanitary point of view, especially in private houses, where there is often objection raised to any

save the "pedestal" form, which is most difficult to keep clean, for it has to have a trap directly

Fig. 13.



The "Beancliffe" Urinal Base.

beneath it formed in the waste pipe, this discharging again into the soil pipe. It is best, where

a "pedestal" is insisted upon, to make the waste pipe of glass-lined iron piping, so that uric acid, if it adheres, can readily be cleansed by flushing with dilute acid: but even then the trap is likely to become full of urine only, for few water companies will permit a constant flush. An automatic flush at short intervals, or set in action when the "base" is stepped upon, is best.

Much better than the pedestal form at all, and under all circumstances, is a slightly sloped but almost vertical back of slate, marble, or enamelled iron, with a sparge-pipe or other simple flush along the whole of the back, constant or automatically intermittent at short intervals, and with an open trough at bottom, leading through the wall to a trap in the open air, without the building. A good base is that shown in Fig. 13—the "Beancliffe Urinal Base"—where this trough is shown falling to the front, where it is carried along the series of urinals, having an iron grating which can be lifted for cleaning with a broom at any time; and this is most valuable, in fact necessary, in the base to any such urinal, in which, also, the whole floor must be so contrived as to fall towards the channel for cleansing purposes.

CHAPTER V.

RAIN-WATER, WASTES, AND OVERFLOWS—STABLE DRAINAGE.

It is of course absolutely essential that all rain-water pipes, with their heads necessarily below the eaves of a building, and often with comparatively imperfect joints, should be completely disconnected from the house drain. This is usually attempted by placing a trap at the foot of the pipe, but such a trap can in no way be depended upon, as in time of drought the water in it necessarily evaporates, leaving a clear passage for any sewer gas which may be in the drain. A better thing to do is to discharge all rain-water pipes at the ground level over a grating or, better still, into an open channel leading to a grating, beneath which is a circular trapped gully, thus interposing not only a trap, itself within view and easily reached by raising the grating, but also an air space, between the down-pipe and the drain. Such gullies should be circular on plan and with no angles whatever, so that collection of matter is rendered well-nigh impossible, and cleaning easy, while then the outlet can be laid in any direction without the awkward appearance of a square gully set diagonally in a pavement. The

outlet must be to an even fall, and is best made to an inspection chamber; but it must in no case be very long, as it is an unventilated length of piping. Thus it becomes necessary often to connect direct to soil drain, with a side junction, of course in the direction of the flow; and this can safely be done provided the length of pipe be long enough, say 8 to 10 feet long, to prevent the syphonage of the trap on the greatest possible discharge taking place down the soil drain; i. e., that from a flushing cistern or tank. An even better plan, again, is to adopt the system shown in Plate A, where all clear water discharges are taken to untrapped gullies, and thence by pipes to disconnecting chambers having fresh-air inlets, or open grids, which are trapped off from the disconnecting chamber of the soil drain into which they discharge in precisely the same way as that is from the sewer.

Wastes from lavatories, baths, and butlers' sinks should be treated in precisely similar fashion, and may, in fact, discharge over the same gullies as the rain-water pipes, as both may discharge into the gully to be mentioned presently as the one to use for scullery sinks, and, in fact, the lavatory and bath wastes, discharging much grease in the form of soap, are best led to that gully if it can be done. Of course all such wastes must be trapped directly beneath the outlet from bath or lavatory, and the best traps to use are, without question, Du Bois' drawn-lead traps, hydraulically drawn without

seam, and provided with screw trap at the bottom of bend, which can be opened for cleaning when required. The wastes from lavatories and baths on upper stories, with their long lead pipes, carried, as they should be, outside the house, are liable to become coated with grease, and consequently should have their outlet ventilators above the roof like a soil-pipe, unless air disconnection by means of rain-water heads be provided halfway up the building. Long pipes, where unavoidable, for the carriage of grease water, are undoubtedly best of glass-lined iron, but this is expensive and rarely used. It is best for all overflows to discharge directly into open air, so that the fact of the water overflowing may be at once apparent. Every such overflow should be provided with a small copper flap valve at the outlet, to prevent the admission of cold back draughts.

All lavatories and baths should be provided with lead safes beneath them, with overflow, treated in precisely the same way as the safes under closet apparatus previously mentioned.

Of the form of lavatory basin to use, it is safe to say that the simpler it is the better ; nothing being preferable to a simple basin, with plug at bottom attached to a chain, fitting into a brass or gun-metal socket, with grating to prevent anything solid from being discharged into the waste, the overflow outlet being formed of a similar simple brass grating. The taps then overhang the basin and are distinct from it—the best being Lord Kelvin's

new patent screw-down taps. In busy public lavatories it is necessary to provide tip-up basins, so that they may be emptied rapidly, and care must be taken to select a pattern which enables the basin to be lifted out, and its casing periodically cleansed.

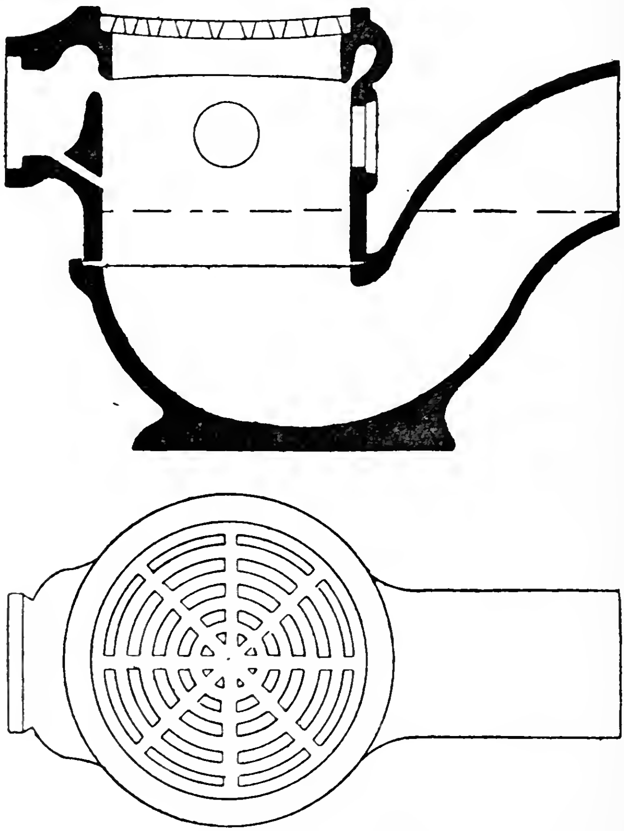
The same remarks apply with equal force to baths: all parts which are movable, likely to get out of order, or to become choked with grease, should be avoided.

The overflows from all cisterns—and *all* cisterns should be provided with overflows—should be discharged in the open air as quickly as possible, and in positions where foul gases from water-closets or urinals, or gullies which might at any time contain grease or vegetable water, cannot possibly rise up them ; and they should be provided with small flap valves at their outlets.

The discharges from scullery sinks have to be treated somewhat differently, so far as the gully is concerned, on account of the large amount of grease and vegetable water discharged from them. Many forms of grease traps have been invented, but experience has shown that they as a rule cause greater evils than they prevent, and it is now very generally admitted that it is best to connect such wastes to a gully having a deep seal and large water area, such as that made by Winser, and shown in Fig. 14, in which any grease which may be discharged into it has time to cool and solidify. The gully is provided with a large inlet for the flush

from a flushing tank, and with a flushing rim, so that when the periodical flush takes place (the tank being automatic in its action), the solid grease is

Fig. 14.



Flushing Grease Gulley.

broken up and carried right out at once into the sewer, without having any opportunity of adhering to the pipes. The amount and frequency of the

flush should depend upon the rapidity with which the gully may be estimated to become full of grease, but as a rule a 30-gallon tank discharged once a day will suffice for an ordinary house.

In order to obtain the greatest amount of good from this flush it is advisable to place the discharge from scullery sink as near to the head of the house-drainage system as possible, so that the whole system is flushed at each discharge.

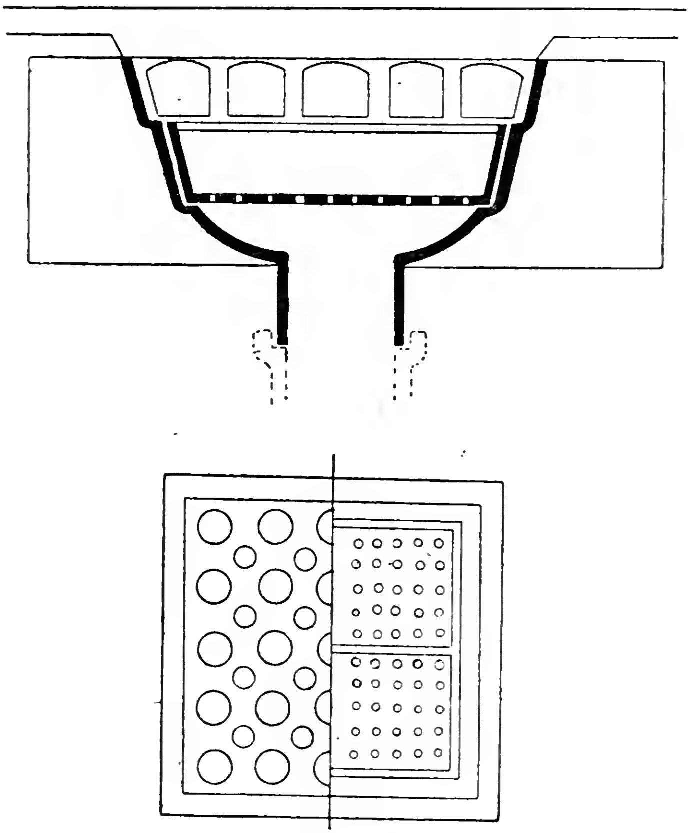
Scullery sinks are much best of glazed stoneware; but of whatever material they may be made, their outlets should be through a simple fixed grating to the lead pipe under, the pipe being of 2-inch bore, and being immediately trapped with a deep drawn-lead trap.

It is advisable that no trapped gully be allowed within a dwelling. Such should *always* be in the open air, and with an open galvanised iron grating over them which at any time can be lifted to allow of their being cleansed in the event of stoppage. This, of course, affects the construction of the floors of paved sculleries, laundries, &c., which should be laid to falls, with slight surface channels if they be large, leading to larger channels, covered with movable iron gratings, these leading through wall and discharging into a grease gully outside, with arrangement for flushing as mentioned above. The outlet of course should be provided with flap valve to prevent the admission of cold air. Some authorities, however, prefer to secure this result by using a gully and trap just within the building,

discharging from this again, in the open air, over the grease gully.

This leads naturally to the consideration of

Fig. 15.

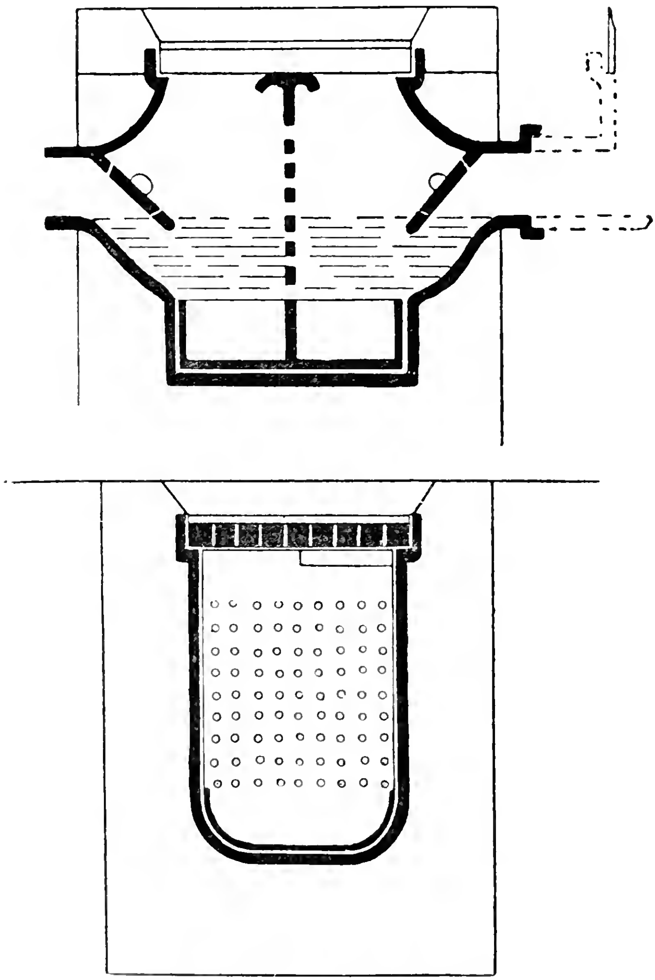


Stable Gully.

stables, which should be treated much in the same way. Here, again, no trapped pot or gully should be permitted within the building, for such traps are

there generally but unhealthy urine traps. The

Fig. 16.



Intercepter for Stable Drainage

floors of the stalls and boxes should be laid to falls, with slight surface channels (a hard concrete floor,

channelled, is better than a brick one, having no joints), leading to main channels covered with removable iron gratings, so that straw is normally kept out, but that all may be cleansed with water and a broom. These channels may safely be led to an untrapped pot or hopper, such as that shown in Fig. 15, placed just inside the outer wall, the connection being thence to a special form of open trapped gully in yard just outside the stable, an excellent form being Ward's, shown in Fig. 16, with collecting box for any solids which might get so far, and strainer to prevent their passing into drain beyond. There are objections to collecting boxes and to strainers, but in the case of stable drains they seem to be necessary evils.

Once beyond the gully trap the drain should be treated precisely as a house soil drain, with proper provison for inlet and outlet ventilation, and disconnection from sewer—to which it should flow through a distinct system of pipes of its own, though it can, upon emergency, be connected, in an inspection chamber, to the soil drain of a house.

CHAPTER VI.

PROVISION FOR FLUSHING.

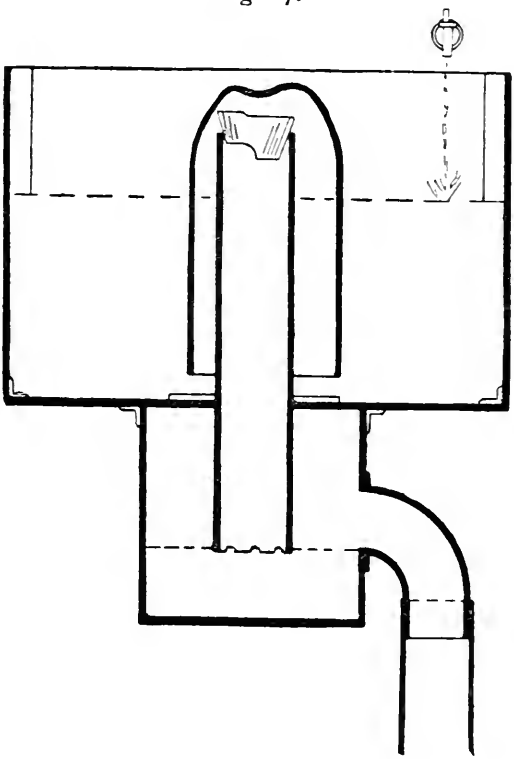
WHENEVER it is possible, and in almost all cases it is possible, provision should be made for the periodical flushing and complete cleansing of house and stable drains. This is best accomplished by the use of an automatic flush tank, of not less than thirty gallons capacity in a small house, and ranging from this to any required size, supplied from the main or from the storage cistern where such is used, by a regulated dribble, so as to discharge at known intervals ; and this tank should theoretically be placed at the head of the drainage system, so that when discharged it may sweep it throughout. In many cases it is most convenient to discharge it into the grease gully outside the scullery mentioned in the last chapter, which, consequently, should itself be near if not quite at the head of the system.

The best form of flush tank is undoubtedly that which discharges through a syphon, the added head of water causing great rapidity of flush, probably the best of all being the modern improved pattern designed by Mr. Field, himself the first to introduce the syphon cistern. In any case the tip-up flush tanks should be avoided, as they necessarily are

pivoted on centres, and revolve in chambers, which in course of time become excessively foul.

Field's flushing cisterns, one of which is shown in Fig. 17, made upon precisely the same system as

Fig. 17.



Field's Flushing Cistern.

his flush tanks, only much smaller, are often, and most satisfactorily, employed for automatically flushing urinals; and in cottages and tenement houses, and in other positions where those using

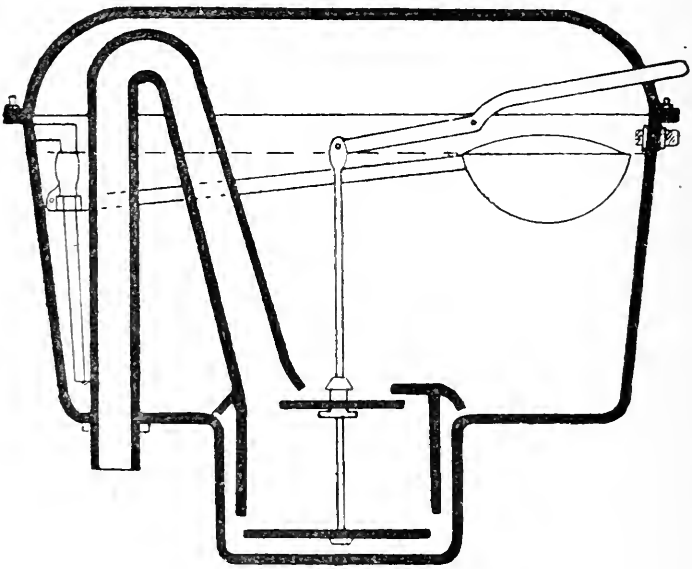
the closets could not be depended upon to pull a chain or plug, are the best things with which to flush water-closets also, for they not only provide a definite flush at definite intervals, but, having an air space between the surface of the water contained in them (themselves always forming a trap) and the tap by which the necessary dribble of water to set them in action is admitted, provide against any contamination of the water supply from the closet apparatus.

This is obtained in any form of disconnecting flushing cistern, whether automatic or worked by hand, by means of chain or plug. Of these latter there are many good forms, but preference should always be given to those with fewest movable parts, and which discharge through a syphon—to secure a rapid discharge of water and so that the full effect of the flush is obtained. This is of great importance, as most water companies have power to limit the supply of water at each discharge to a ridiculously inadequate amount. A three-gallon flushing cistern should be the smallest used, and this should be of the syphon form and discharge through a 1½ or 2-inch pipe. The form illustrated in Fig. 18 is Milton Syer's "Peckham." Care must be especially taken to provide each flushing cistern with an overflow pipe below the level of the elbow of the syphon, else any overflow will take place through the syphon and cause great and unnecessary waste of water.

A new form of cistern, and seemingly a very

good one, is that introduced by Mr. Jennings, and named "The Cistern of the Century," illustrated in Fig. 19. The lever raises a plate, throwing enough water over the top of the syphon to set it in action. The discharge is rapid and silent, and when it is nearly complete, and not till then, the longer

Fig. 18.

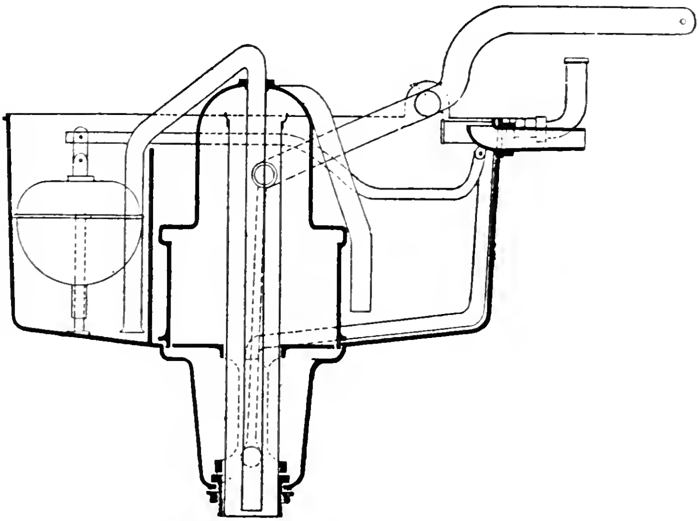


The "Peckham A 1" Syphon Cistern.

syphon is set in action by the pull of the main syphon, and the small chamber containing the ball-valve is rapidly emptied, an after-flush being thus formed. Thus no water is admitted until the cistern is empty. Similarly, this isolation of the ball-valve allows of the tap running full bore until the cistern is full, when the water overflows into

the ball-valve chamber, and raises the valve rapidly. Silent and rapid, both in discharge and refilling, it is a most useful cistern to employ in busy public latrines, though it was specially designed for use with Jennings' "Century" closet. When so used, it must be noted that if discharged before it is full, there will be no after-flush.

Fig. 19.



The "Cistern of the Century."

Where valve closets are used, a limited supply of water is almost valueless, and then it is quite necessary to have a storage cistern of 50 gallons capacity per closet supplied, and not only used *exclusively* for the supply of closets, urinals, and overflow slop sinks, but placed in such a position that by no possible means can contamination be conveyed from it to any drinking-water storage

cisterns. They should not only be distinct, but in different parts of the building, covered and yet well ventilated and readily accessible.

Where there is a constant supply from waterworks there should be no storage cistern for drinking water: it should be drawn direct from the main, which in the house would then have to be of stout lead piping and provided with screw-down taps. Lord Kelvin's, already mentioned, are the best, so far as can yet be judged; for they are of comparatively recent introduction, and new things must generally be received with a certain amount of caution.

CHAPTER VII.

DRAIN TESTING.

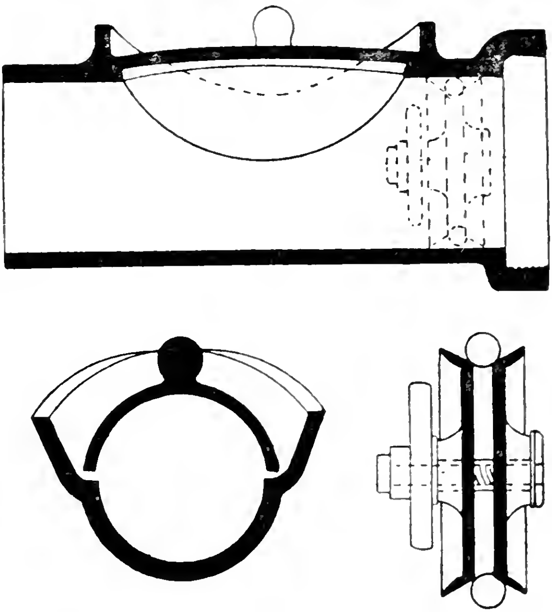
A MOST important matter is the thorough testing of drains and soil pipes after they are in position, to make certain that both pipes and joints are sound.

The drains must be tested before they are covered in—when everything is otherwise perfectly finished, all inspection chambers built, all gullies in position, and the bends formed for connections from soil pipes. Everything should first be carefully inspected, to see that the pipes are properly supported throughout their length, in straight lines from point to point, and with no cement of which the joints are made protruding into and obstructing the pipes—which, when looked through from inspection chamber to inspection chamber should appear as smooth and true as a gun-barrel. Then all junctions should be noticed, to make sure that they discharge in the direction of the flow of the main pipe, and not so that the discharge from one may block up the outlet from another—this whether junctions are formed in inspection chambers or elsewhere—and the inspection chambers themselves need careful inspection to ensure that the floors all slope towards the drains.

It is now usual to test the intercepting trap and disconnecting chamber as well as the whole system of drainage, and for this purpose an access pipe (such as that shown in Fig. 20, with a lid which, after the test has been applied, can be cemented down, leaving the original section of the pipe intact) should be inserted between the trap and the sewer, and so as to form the very next length of pipe to the sewer if possible,—and it generally is possible. In this access pipe is inserted a drain plug, the most usual form of which consists in a rubber ring, of slightly smaller diameter than the pipe, held in position by two plates of wood or metal, which, when screwed together by a thumb-screw connecting them, squeeze out the rubber until it bears sufficiently tightly against the pipe to prevent anything from passing even when under considerable pressure (see Fig. 20, which shows such a plug in position). Water is then allowed to run into the system of drains, care being first taken to provide against any section becoming air locked by running short pieces of compo gas piping through all gully traps, by means of which the air can escape as the water rises in the pipe—and the whole system of drain pipes, inspection chambers, and disconnecting chamber must be completely filled with water up to the level of the top of the highest gully on the system. This should be left to stand for some period of time (half-an-hour at least), and at the end of that time, if everything be perfect, there should be no subsidence whatever. Should the

level of the water have at all subsided it is evidence of a leak, which would have to be traced—and if it be not evident to the eye on further inspection of the exposed pipes this will often be most readily traced by the slow process of testing the drain again in sections. Sectional testing is also neces-

Fig. 20.



Winser's Access Pipe and Testing Plug.

sary if the fall be rapid, else one gully may overflow before the pipe is full, and also because a head of water of more than ten feet is too severe a test, and may weaken the joints if they be not fully set.

Some of the better forms of drain plugs are so made that when it is desired to release the water

after the application of the test it can be let out gradually, by removing a screw cap covering a small pipe through its axis: but this is a matter of comparatively small moment.

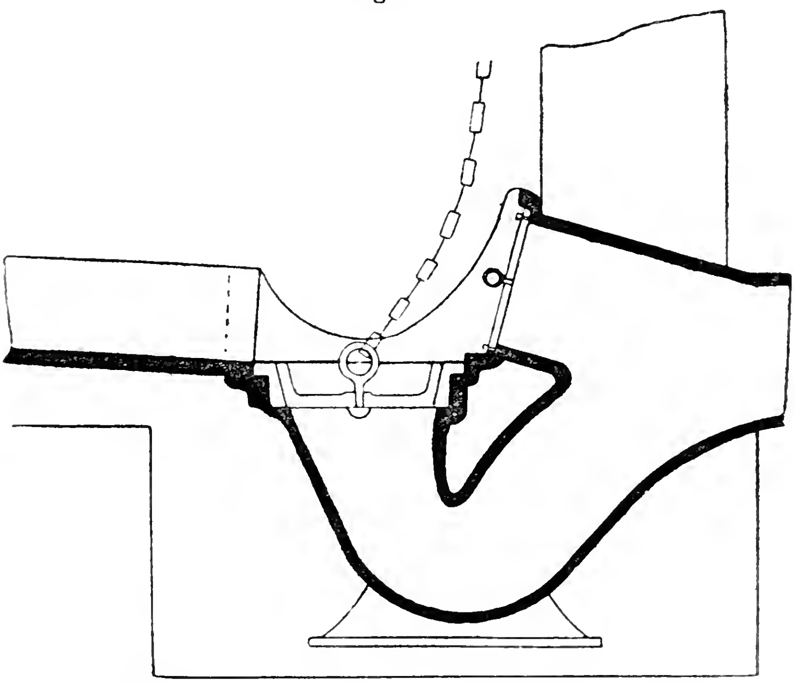
It must be distinctly borne in mind that no system of testing drains can be considered to be satisfactory save that described above.

Vertical soil pipes, however, particularly if of lead, would be weakened by the application of so severe a test, while no useful purpose would be served, as they are scarcely so liable as the drains to become waterlogged, and were this to happen would soon, unlike underground work which might leak for a long time without detection, show plainly that something was wrong. These can be tested perfectly satisfactorily by means of smoke, all closet traps being first filled with water and so sealed, the outlet ventilator plugged with a drain plug, and then some powerful smoke-producing apparatus set to work at the foot of the pipe—or where the soil pipe is but a short one a smoke rocket or two will suffice, care being taken by covering with sacking that the smoke goes only up the pipe. Any leak through which sewer gas could escape will very readily be seen by the escape of smoke through it, if the pipe be really filled with smoke, as it should be, to the extent of its capacity.

For testing old soil pipes which it is not wished to disconnect at the foot, as would be necessary in order to apply the smoke test, Banner's drain-

ferrets are valuable. They are small vials of thin glass, containing a substance which emits a most pungent odour on the vial being broken—and this is accomplished by merely passing it with the ordinary flush through the uppermost water-closet

Fig. 21.



"Detector" Combined Drain Plug and Intercepting Trap.

trap. There are now (1894) several similar and equally good appliances on the market. Many people use oil of peppermint, or ether, to achieve the same result, pouring them, mixed with hot water, down the uppermost water-closet on the

stack; but these are smell tests only, by means of which the actual position of a leak cannot be ascertained, and may fail altogether should there be any careless handling of the material used.

For use in places where, from propinquity of the disconnection chamber to the boundary of property, or from any other reason, an access pipe cannot be inserted, a combined drain plug and intercepting trap, for use in the chamber, has recently been patented, and is being manufactured by Messrs. Winser & Co. This is illustrated in Fig. 21, and consists of a trap, with gun-metal plug and seating, ground to fit accurately, the plug having a chain attached by means of which it can be lifted to allow the water in the chamber to escape after the test has been made. The plug is of course kept always suspended in the chamber ready for use at any time.

CHAPTER VIII.

A MODEL SPECIFICATION FOR HOUSE DRAINAGE.

THIS chapter has been added to the original scheme of this treatise upon the request of some students working under the author, and is given as upon consideration he thinks that it may be valuable to others also. The specification is not intended for any one particular piece of work: it is to be taken as a model only, to be adapted to the exigencies of each particular case as circumstances may require, some of the items being given in alternative, to meet common alternative cases.

It must, moreover, be borne in mind that even the most perfect of specifications is valueless unless there be careful supervision to ensure its provisions being absolutely followed. In particular, wherever tests are mentioned in the specification they should be applied, and, no test should be mentioned in the specification which it is not within both the architect's intention and his ability to carry out.

SPECIFICATION of Materials to be used and Work to be done in the Drainage of
for under the direction and superintendence of ,
by whom the specification has been prepared, and in accordance with the accompanying plans numbered 1 to and with this specification.

A. B.
Architect,
Blankington.
18

GENERALLY.

Materials and Labour.—Provide all materials, appliances, and labour necessary for the due and proper completion of the works in accordance with the true intent and meaning of the plans and this specification taken together.

Notices and Fees.—Give all notices and pay all fees which may be legally necessary.

Foreman.—Keep a proper and responsible foreman constantly upon the works, to whom directions can be given.

Class of Work.—All materials, workmanship, and appliances are to be of the very highest class. Any which falls short of this standard is immediately to be removed and reinstated with first-class materials and workmanship on the order of the architect.

MATERIALS.

Cement.—All cement is to be Portland, to stand a tensile stress of 900 lbs. per briquette area of $2\frac{1}{4}$ inches after being made into a paste, allowed to set in air for twenty-four hours, and then immersed in water for seven days; to leave a residue of not more than 10 per cent. on being passed through a sieve of 2500 meshes per square inch, and not to disintegrate, after being made into a briquette and allowed to set for twenty-four hours, if kept in water for three days at a temperature of 100° F.

Sand.—All sand is to be sharp pit sand, free from salt or earthy matter.

Concrete.—The concrete is to be composed of four parts of broken bricks or crushed stone, in pieces so small as to pass in all directions through a 2-inch ring, two parts of sand, and one of Portland cement, well mixed together in a dry state, wetted with just sufficient water through a rose, turned over rapidly twice and shovelled quietly into place, and lightly rammed till the scum rises to the surface.

Bricks.—All bricks are to be hard and truly shaped blue Staffordshire bricks, completely vitrified throughout.

Stoneware Pipes.—All stoneware pipes are to be socketed, circular, perfectly true in line and section, vitrified throughout, and completely salt-glazed.

Other Stoneware.—All other stoneware is to be

true to its shape, and similarly vitrified throughout, and completely salt-glazed.

Iron Pipes, &c.—All ironwork is to be cast of good grey iron, free from bubbles and scoriæ, and true to shape, and all iron pipes are to be cast vertically, with core truly kept, and to be coated with Dr. Angus Smith's preparation.

Lead Pipes.—All lead pipes are to be of drawn lead holding the full weight specified, and all lead traps are to be drawn.

Milled Lead.—All other leadwork is to be formed of milled sheet lead holding the full weight specified.

Stone.—All stone is to be out of hard York landing, free from cracks and vents, and laid on its natural bed.

Appliances and Workmanship.

Excavation in Bulk.—Excavate for all disconnection and inspection chambers, and for the foundations thereof, to the sizes shown on plans, and place soil where directed on site. Plank the sides if necessary, and fill in and well ram the returned earth after the whole system has been tested and passed.

Excavation for Trenches.—Excavate for drain trenches where shown to even falls as great as can be obtained from point to point, with double fall round all bends. Sink in bottom of trenches for sockets of pipes. Plank the sides if necessary, and

fill in and quietly ram the earth after the drains have been tested and passed.

Remove Earth and Leave Tidy.—Remove all surplus earth and rubbish on the completion of the work, make good to flower beds, grass plots, and gravel and other paths, and leave all clean and tidy on completion.

Concrete Bottom to Chambers.—Form concrete bottom to all inspection and disconnection chambers, 18 inches longer and wider than outside dimensions of brickwork, and one foot thick below invert of lowest pipe. Bed in pipes and traps afterwards specified, and form floor of chamber to quick slopes falling towards open pipes.

Render in Cement.—Render floor and walls of chamber when finished in cement and sand in equal parts, with dry neat cement trowelled into surface before it is fully set.

Concrete Bed for Pipes.—Form concrete bed for all drain pipes, laid in trenches to even slope, 18 inches wide and 6 inches thick below invert of pipe, inserting a brick wherever sockets of pipes will come, these bricks to be removed when pipes are laid, and the space made good in concrete after the drains have been tested and passed.

Casing Pipes in Concrete.—All drain pipes which pass beneath buildings are, after they have been tested and passed, to be entirely cased in concrete, which shall be nowhere less than 6 inches thick.

Block at Foot of Soil Pipe.—Where vertical pipes drop into socket of bend of drain pipes the con-

crete is to be carried up in a block so as to cover the joint to a depth of 6 inches—after the drains have been tested and passed.

Inspection and Disconnection Chambers.—The walls of the inspection and disconnection chambers are to be of 9-inch brickwork in English bond, laid in cement and sand (equal parts.)

Stone Heads.—Wherever pipes pass through brickwork, whether to chambers or to house walls, the superincumbent weight is to be carried by stone heads 4 inches thick above extrados of pipe, with 4 inches bearing on each side at level of centre of pipe, for which they are to be sunk.

Stone Curb.—Form 9-inch by 16-inch rebated stone curbs to receive iron covers, and bed same in cement.

Iron Cover.—All inspection and disconnection chambers on soil drains are to have (*maker's name*) air-tight manhole covers, subjected to the Bower-Barff preservative process, and complete in all respects.

Open Grids.—All inspection and disconnection chambers on fresh-water drains are to have open iron gratings, made to lift out, with iron tray beneath to prevent earth and stones from falling through into the chamber. These must be raised 2 inches above the surrounding ground.

Fresh-air Inlet.—From disconnection chambers on soil drains carry up a short 4-inch pipe with bend, 2 feet above ground level, against a wall or fence if there be one near, and finish with circular

mica-flap air inlet, having the flap hanging on hooks. This is to be of galvanised iron and complete in all respects.

Lay Drains.—Lay the drains of stoneware pipes (save under carriage ways, when they are to be of iron pipes) of the sizes and as and where shown on drawings, upon the concrete bed prepared for them, to even falls save at bends, when the fall is to be doubled, and in perfectly true straight lines from point to point. All junctions are to be formed where shown in the direction of the flow through main pipe, and all curves are to be formed of bent pipes to easy radius.

Joints.—The joints are to be formed in cement and sand in equal parts, the inside to be carefully wiped out before setting takes place, and the outside to have a fillet of similar material run round.

Access Pipe.—A Winser's access pipe is to be inserted in the drain as near to junction with sewer as possible, and to have cover cemented into place after the drains have been tested and passed.

Traps.—Intercepting traps are to be placed where shown, and are to be (*here describe size and make*).

Pipes in Chambers.—All straight pipes in inspection and disconnection chambers are to be half-round, and on their edges is to rest a course of bricks. All curved pipes are to be flat-bottomed, three-quarter-round to proper radius, and junctions are to be made over the edge of main pipe and in the direction of its flow, none being so arranged as

to discharge into the mouth of another, or to cause any overflow.

Connection with Sewer.—When ground is excavated, and foundation ready for pipes, make connection with sewer under the direction of local authority. Plug in access pipe to prevent exit of sewer gas, as soon as this is reached. This plug is not to be removed until test is applied.

Rain-water Pipes and Fresh-water Discharges.—The discharges from rain-water pipes and other clear wastes are to be made in the open air, over untrapped circular gullies with iron gratings over, having 3-inch sunk and dished stone curbs.

(*The above is for such a system as that shown in Fig.* 1, *where the clear waters are taken to a disconnection chamber before being discharged into the soil drain.*)

Alternative.—The discharges from rain-water pipes and other clear wastes are to be made in the open air over circular trapped gullies with iron grating over (or are to be made over untrapped gullies and thence led to a trapped gully where several are collected), having 3-inch sunk and dished stone curbs, and thence to be taken to the nearest inspection chamber on the soil drain.

Grease Gullies.—All discharges from scullery sinks, lavatories, baths, or other greasy wastes are to be made in the open air on to or into the sides of a (*maker's name*) Flushing Grease Gully properly connected to the nearest inspection chamber on the soil drain.

Flushing Cistern.—This gully is to be supplied from an automatic syphon flushing cistern of...... gallons capacity, to be fixed (*describe where and how*), and arranged so as to discharge once every ... hours. It is to be (*describe make, &c.*), and is to be connected with gully by a stout (...)-inch drawn-lead pipe.

Soil Pipes.—All soil pipes are to be of drawn lead, 4 inches diameter, and weighing not less than 8 lb. per foot run. They are to have wiped joints, to be secured to wall by lead tacks (*or lead flanges*) not more than six feet apart, to have all junctions bossed out, and are to be carried up full bore above topmost water-closet, of full weight and thickness, to 5 feet above eaves of building or of the nearest dormer window, and to terminate with Stevens' cowl, to prevent down-blow and to act as outlet ventilator.

The junction with stoneware pipe at foot of soil pipe is to be made with copper (or brass) ferrule, with flange to fit into socket, wiped on to lead pipe and let into socket with sulphur (or cement and sand in equal parts).

Connection from Water-closets.—Connect from each water-closet apparatus to this soil pipe with similar piping, jointed with (*state how*).

Anti-syphonage Pipe.—From bend of trap of lowest water-closet on the series take a 2-inch stout lead pipe through wall, and carry it up outside house, connected by tacks to brickwork, joining to

it a similar pipe from each trap above, and finally connecting it to soil pipe when not less than 3 feet above the whole series of closets.

Apparatus.—All water-closet apparatus are to be (*here describe make fully*) with trap, complete in every respect.

Seat and Casing.—(*Here describe the seat and casing, if any. The latter, if used, should take to pieces readily, but is better omitted.*)

Flushing.—(*Here describe the method of flushing and supply to water-closet, which must depend on the apparatus used.*)

Lead Safes.—Form lead safes (*or fix stoneware sinks*) under all water-closets, baths, and lavatory basins, of 5 lb. lead, bossed up at angles, and with sides turned up two inches. Carry wastes thence, discharging in prominent places in the open air, with small copper flap valves at outlets.

Overflows.—Carry similar pipes, with similar flaps, into open air as overflows from all flushing and storage cisterns, baths, and lavatory basins.

Wastes.—All wastes from sinks, baths, and lavatory basins are to be formed of stout lead pipes (*give diameters*), trapped with Du Bois' drawn-lead traps, with access screw, immediately under plain brass or gun-metal grating, and to discharge in open air over gullies previously mentioned.

Testing.—The whole system will be thoroughly tested in every way by the surveyor, the water test being applied to drain pipes and the smoke test to

soil pipes, and any defect which may then become apparent, or which may show itself within three months of the completion of the work, shall be rectified immediately by the contractor at his own expense.

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